Health Effects of Western Region Illegal Gold Mining

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Objectives of Presentation:

1. To Create awareness of health-hazards of ‘potable’ water in Western Region
2. To Inform Health-Professionals about the state of research and progress
3. To Propose Solutions to Ghana Government

I. Index

II. Reference-categories

That is at Water

the Core of Pollution!

1. Introduction:

Farmers complained that Chinese workers and managers left the agricultural fields around the Tarkwa mines in a deplorable state, after work in the Tarkwa mines, in 2015.

Only by complaining this pollution came out in the news. I heard about this environmental disaster from a geologist, October 2015. And even a report in January 2016 of the C.A.C. did NOT mention this incident. Which is a shameful performance of this 'co-operation' in the light of the China-African Union Co-operation Platform (founded in the same year, when the African Union was constituted, in South-Africa, 2000).

For me, that news in 2015 was an impetus to set up the website https://www.cross-africa-irrigation-project.org/new, **(in Jan. 2019 changed to** https://irrigateafrica.net**), a proposal for a comprehensive irrigation system for Africa, cq an African Environmental Protection Agency – C.A.I.P., Cross-Africa-Irrigation-Project.**

The main issue in that C.A.I.P. - Project was and still is, to deal with THE CONFLICT OF INTERESTS between

- **Mining-activities with consequent Health-concerns on one hand:**
- **Irrigation meeting Health-concerns: the paramount opportunities and rights for the People of Africa in Agriculture and Health-improvement, on the other hand! For Ghana, embodied in her Constitution. In practice: a conflict between stake-holders.**

IMPACTS OF GALAMSEY ON 3 LEVELS:

1. Impacts of interference with Natural Topography and Drainage Courses:

. by excavations, pits heaps of earth material that are continuously changing the topography and courses of drainage lines
. risk of falling into pits and dying, pit collapse and mud flow or slope failures, flood and dust pollution.
. danger to, and destruction of nearby roads, rail lines, buildings, farms, etc..

2. Impacts of Refuse Dumping on Sanitation and Waste Management

- Dumping of refuge in the swamp and pits, leaching, and erosion from refuse into stagnant waters, streams, into people's houses during flooding in the raining seasons pose serious sanitation and environmental health problems:
  . epidemic cholera, malaria, (and other) diarrhoea and skin diseases.
  . locations of Galamsey activities within the communities are mostly inaccessible to waste collection services by the district assembly.

3. Impacts of Obstruction on Flooding

The consequences documented over the past decade include:
- submerging houses, roads, rail lines, schools and other structures within the flood plains and along spurs.
- collapse of walls, buildings and slopes, mud flow, waste flow and washing away of bridges, and
- loss of properties and lives, and closure of schools, roads, and other service centres."







Artisanal Gold Mining and Mercury Contamination of Surface Water as a Wicked Socio-Environmental Problem: A Sustainability Challenge?

Frederick Ato Armah [1,2*]

The Facts (in 2011):

- Artisanal gold mining (ASM) is the single largest demand for mercury in the world.

- An estimated 1400 tonnes of mercury were used by ASM miners globally in 2011

- ASM is the largest source of mercury pollution to air and water combined.

- Today, artisanal gold is the world's second greatest source of atmospheric mercury pollution after coal combustion, according to the UNEP.

- And with gold prices now exceeding US$1,600 per ounce (up from less than US$ 500 in the 1980s), ASM is on the rise.

- Mercury is a powerful neurotoxin that is harmful along with its mercury problem to people, but especially to developing foetuses, and young children.

- It is estimated that between 10 and 15 million artisanal and small scale gold miners worldwide, including 4.5 million women and 600,000 children are exposed to the mercury amalgamation process.

- This process transforms elemental mercury into methyl mercury, one of the most toxic organic compounds and a powerful neurotoxin that works its way up the food chain through bio-accumulation.

- Although ASM is a long-standing component of livelihoods in West Africa, its proliferation is both unprecedented, unparalleled especially in Benin, Burkina Faso, Ghana, Mali, and Senegal.

- In part, the proliferation can be attributed to the global price of gold, which is at the highest level ever (2011).

- Mercury is the cheapest and easiest gold extraction method (my note: in 2011)

- Mercury-free gold extraction methods require more capital, training, and organization than many artisanal gold miners have access to (my note: in 2011).

- The deleterious effects of gold mining-induced mercury pollution in West African countries have, severally, been outlined. For instance, some human health impacts emanating from the use of mercury in gold mining, identified in Benin, Burkina Faso, Ghana, Mali and in Senegal.

- Yet, attempts over the last few decades to regulate ASM and its attendant mercury pollution have met pollution-human health-policy nexus; with chronic policy failure.

In this study, stakeholders, involved in ASM have been identified:

Key stakeholders refer to actors who are considered to have significant influence on the success or otherwise of ASM intervention strategies.

Primary stakeholders are the intended beneficiaries of the strategies while

Secondary stakeholders serve as intermediaries during the implementation of the ASM strategies (e.g., introduction of cleaner and alternative gold extraction technology).

Active stakeholders are determinants of decision making while

Passive stakeholders are affected either positively or negatively by the decisions of others.

Stakeholder	Characteristics	Resource Use	Interest
Artisanal gold miners	**Primary but passive**	Disposal of untreated mining wastewater into surface water, water withdrawal & forest clearing	Economic benefits; do not pay for environmental management and remediation services; periodic use of concessions of TNCs
Farmers, timber- and other land users	**Primary but passive**	Use of land for agriculture & abstraction of timber and non- and non- timber forest products	Economic benefits from continued farming and lumbering land and forest tenure
Transnational Companies (TNCs)	**Primary but active**	Disposal of treated mining waste-water into surface water, water withdrawal & forest clearing, destruction of farms	Economic benefits, corporate social responsibility
Ghana Chamber of Mines (GCM)	**Primary but active**	-	Economic benefits, corporate social responsibility, welfare of TNCs
Local Government Authority	Key, secondary, active	-	Resource Governance & Ecological health of the water bodies, enactment and enforcement of by-laws Ghana
Environmental Protection Agency (GEPA)	Key, secondary, active	-	Ecological/environmental health of the lagoon; enforcement of gold mining regulation and laws
Traditional Rulers and royal Stools	**Key, secondary, active**	**Cultural use of the land**	**Custodians & Sustenance of the cultural practice, history and beliefs associated with the land**

Stakeholder	Characteristics	Resource Use	Interest
Civil Society (Local & International NGOs)	Key, secondary	-	The ecological/environmental restoration of water bodies; livelihoods, economic, social & political empowerment of gold mining communities
Ministry of Tourism (MT)	Key but primary	forest tourism	Business/economic benefits, maintenance of aesthetics of the forest ecological zones
Ministry of Local Government & Rural Development (MLGRD)	Key, secondary, active	-	Implementation and supervision of resource use and governance decentralization
Ministry of Water Resources, Works & Housing (MWRWH)	Key, secondary, active	-	Formulation and co-ordination of policies and programmes for Water Supply, Sanitation and Hydrology infrastructure
Ministry of Lands & Natural Resources (MLNR)	Key, secondary, active	-	management of Ghana's land, forest, wildlife and mineral resources
World Bank (WB) & International Monetary Fund (IMF)	Key, secondary, active	-	Funding and facilitation of natural resource & environmental governance (NREG)
Water Resources Commission (WRC) & & Forestry Commission (FC)	Key, secondary, active	-	Management of water resources and co- ordination of water policies; regulation of utilization of forest and wildlife resources, coordination of conservation policies
Minerals Commission (MC)	Key, secondary, active	-	Ensures compliance with Ghana's Mining and Mineral Laws and Regulation
Downstream communities	**Primary but passive**	**Drinking of surface water**	**Water-quality and health risk concerns**

Anticorruption Methods & Tools W.M. UNDP-WWG (October 2011)

A study commissioned by the UNDP, Website: www.undp.org/

Important drivers for anti-corruption measures include:

- political will, related to political prestige, ideology and peer pressure;
- political will, related to downward accountability (pressure from constituency);
- pressure to comply with transparency and integrity rules of international donors;
- mobilization of citizens (especially when they are affected directly by corruption); and
- commitment of private companies.

Important conditions for anti-corruption measures to have positive impact include: (in Ghana???)

- good and fair judicial system (rule of law);
- democratic political environment (at least to some extent);
- free and independent press;
- sufficient staffing at national anti-corruption agencies;
- civil society organizations that serve as corruption watchdogs, and have adequate funding and trained staff;
- whistle-blower protection policies and enforcement

CUSTOMARY WATER LAWS AND PRACTICES: GHANA (per November 2018) G. A Sarpong

The existing regime for regulation of water use is a mixture of customary rules & enactments, according Article 11 of the 1992 Constitution on the 8 sources of laws in Ghana. Article 11.

As to the Ghana Customary Water Laws, esp. 3 to be mentioned:

1. **The Constitution;**
2. **The Common Law – art. 11(2), including Customary Law (Rights and Practices) – art. 11(3): applicable to particular communities in Ghana and, which as to water - have been supplemented or supplanted by legislation:**
3. **The Water Resources Commission Act, 1996, to establish the WRC, assigned**

2a. Comparing Two Statistical Studies made clinical & lab. diagnosis of HM toxicity URGENT in the Western Region:

Introduction:

I. The Multivariate Statistical Analysis is a *Parametric Data Analysis,*

- hypothesizing that a given outcome of interest is effected or influenced by more than one thing.
- popular to test quantitative data, especially of chemical analysis in mines.
- investigating differences: to test the simultaneous observation and analysis of more than one outcome variable at a time (Google):
- a statistical test for quantitative data: collection of methods used when several measurements are made on an object in different samples.
- Other quantitative tests: Paired and unpaired t-tests and z-tests.

II. The Chi-square Statistical Research is a Non Parametric Data Analysis (Google search)

- as a Univariate test, to test how likely it is that an observed distribution is due to chance.
- one of the most common statistical tests for qualitative data.
- because a chi-square test is a Univariate test it does NOT consider relationships among multiple variables at the same time. Therefore, dependencies detected by chi-square analysis may be unrealistic or non-causal.
- the goodness of fit test: it measures how well the observed distribution of data fits with the distribution that is expected if the variables are independent, so: test of independence.

I. **Multivariate Statistical Research** through a cooperation between the Centre for Environmental Impact Analysis and Scientists of the University at Cape Coast was performed before February 2010, published in Research Gate.

Summary Abstract and Conclusion of the Research in 2010:

- **Application of multivariate statistics for the interpretation of surface and groundwater data from Tarkwa, a mining community in the Western region of Ghana, is presented in this study.**
- **Effluents from extractive industries: directly discharged onto surrounding land and surface water bodies constituting point and non-point sources of contamination for ground-water.**
- **In the Tarkwa mining area, large deposits of mine wastes, ore stock-piles, and waste rocks.**
- **Monitored: 12 parameters including trace elements (Cu, Mn, Cd, Fe, Pb, As, Hg and Zn) and physicochemical parameters (pH, conductivity, turbidity and total dissolved salts), on 49 sampling points including surface and groundwater.**

MAIN conclusions quoted:

. **value of multivariate statistical analysis**
. **better policy outcomes and decision-making that positively impacts water quality;**
. **broadly, most of the water bodies in the study area have mean levels of arsenic, iron, mercury, zinc, and lead which are above WHO and GEPA guideline values.**
. **high concentrations associated with high coefficients of variation, therefore, suggest anthropogenic (= by human activities caused) sources for arsenic, iron, mercury, zinc, and lead.**
. **imperative to establish an environmental monitoring scheme to check the concentration levels of heavy metals within the Tarkwa mining area of Ghana."**

II. Chi-square Statistical Research (comparing expected with measured values)

through a cooperation between the University of Mines and Technology in Tarkwa and the Technische Universität, Berg-Akademie Freiberg, Germany and Radford University College, Accra.

Main Conclusions (quote):

- **Among the list of elements that exceeded the guideline, arsenic, manganese, nitrate, nitrite and iron were the most predominant.**

- **The elevated As-levels indicate the weathering of arsenic-pyrite and the leaching of sulphur bearing mine tailings into the subsurface.**

- **Results of on-site measurements and analysis of physicochemical parameters reveal that 55 % of the samples have pH values that are outside WHO's acceptable range.**

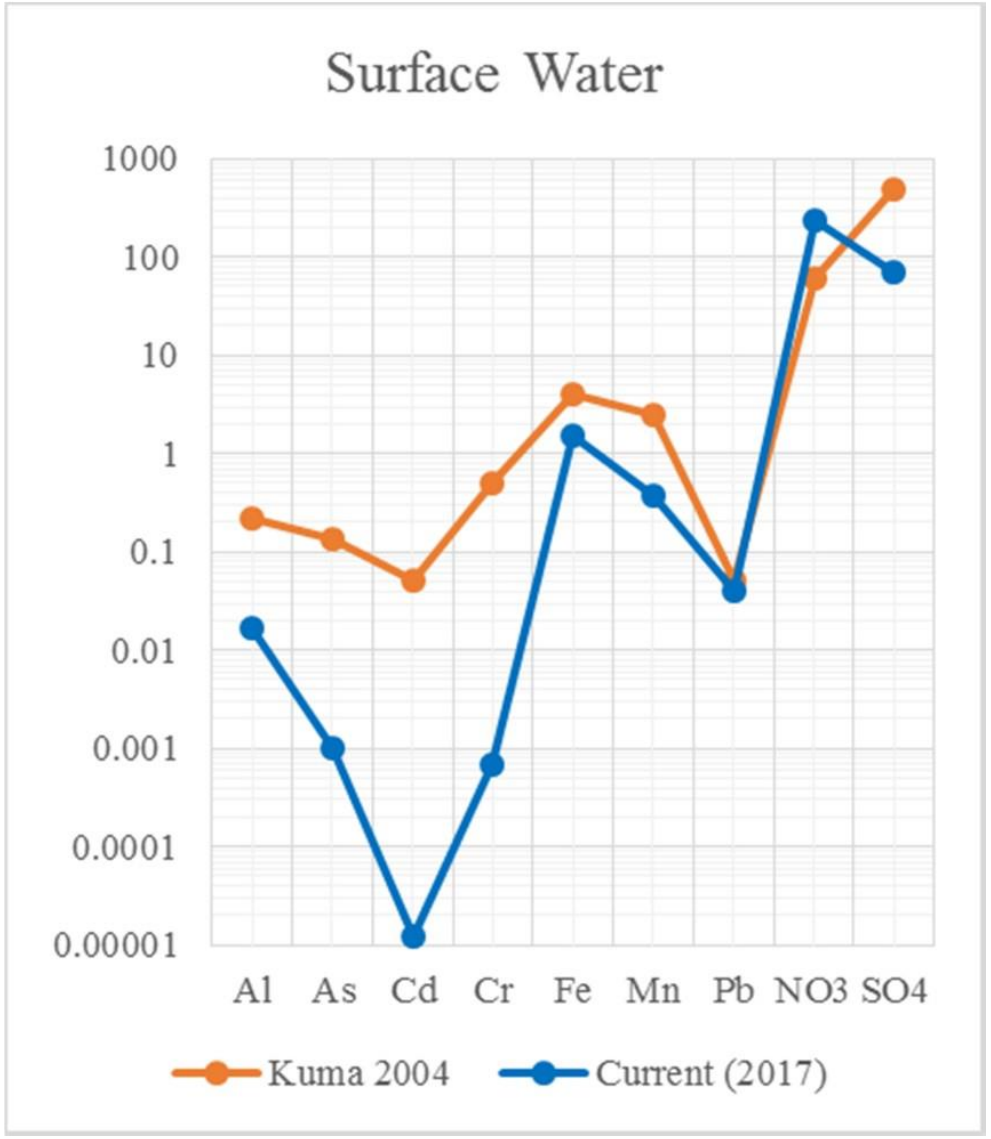
- **Efuanta and Bonsa-river: high concentrations of Fe and SO4 2- coupled with low pH, suggesting the influence of Acid Mine Drainage (AMD) on ground-water.**

- **The general trend of water quality for the Tarkwa area is not as bad as previous studies have portrayed.**

- **This research work together with some recent studies such as Kuma and Ewusi, (2010), show that the trend of metal distribution has seen improvements in concentration levels."**

Table 2 Results of Modelling with PhreeqC showing the Distribution of Species

Mineral	Species	Samp. 3 (%)	Samp. 11 (%)	Samp. 15 (%)	Samp. 22 (%)	Samp. 29 (%)
Fe(2)	Fe^{+2}	1.34	93.99	89.53	77.19	97.33
	+					
$FeHCO_3$	0.14	5.55	4.88	20.35	0.00	
	$FeCO_3$	0.11	0.00	0.06	1.28	0.00
	$FeSO_4$	0.03	0.33	4.73	0.40	2.31
	$FeOH^+$	0.03	0.00	0.03	0.17	0.00
	$FeHPO_4$	0.00	0.00	0.01	0.41	0.00
	$FeCl^+$	0.00	0.07	0.14	0.01	0.31
	+					
FeH_2PO_4	0.00	0.06	0.02	0.16	0.04	
Fe(3)	$Fe(OH)_3$	82.98	0.00	0.09	0.02	0.00
	+					
$Fe(OH)_2$	8.52	0.01	0.54	0.03	0.00	
	-					
$Fe(OH)_4$	6.87	0.00	0.00	0.00	0.00	
Al	-					
$Al(OH)_4$	99.30	0.00	28.10	0.00	0.00	
	$Al(OH)_3$	0.64	0.00	11.05	0.00	0.00
	+					
$Al(OH)_2$	0.05	1.55	54.20	0.00	0.22	
	$AlOH^{+2}$	0.00	11.82	5.65	0.00	4.05
	Al^{+3}	0.00	82.36	0.59	0.00	73.96
	+					
$AlSO_4$	0.00	4.25	0.39	0.00	21.64	
	-					
$Al(SO_4)_2$	0.00	0.00	0.00	0.00	0.12	
Pb	$PbCO_3$	93.56	0.50	23.48	78.74	0.00
	-2					
$Pb(CO_3)_2$	1.76	0.00	0.00	0.27	0.00	
	$PbOH^+$	1.61	0.02	0.81	0.53	0.01
	Pb^{+2}	1.56	66.25	45.90	6.56	83.84
	+					
$PbHCO_3$	1.32	31.06	19.87	13.74	0.00	
	$PbSO_4$	0.11	0.71	7.20	0.10	5.94
	+					
$PbNO_3$	0.06	0.00	0.53	0.00	1.77	
	$Pb(OH)_2$	0.04	0.00	0.00	0.00	0.00
	$PbCl^+$	0.01	1.44	2.19	0.04	8.39
	-2					
$Pb(SO_4)_2$	0.00	0.00	0.02	0.00	0.01	
	$PbBr^+$	0.00	0.00	0.00	0.00	0.01
	$PbCl_2$	0.00	0.00	0.00	0.00	0.03
Mn(2)	Mn^{+2}	71.64	94.52	90.22	77.17	96.79
	$MnCO_3$	19.69	0.00	0.21	4.23	0.00
	+					
$MnHCO_3$	6.82	4.97	4.385	18.14	0.00	
	$MnSO_4$	1.69	0.34	4.78	0.40	2.31
	$MnOH^+$	0.13	0.00	0.00	0.01	0.00
	$MnCl^+$	0.03	0.20	0.40	0.04	0.91



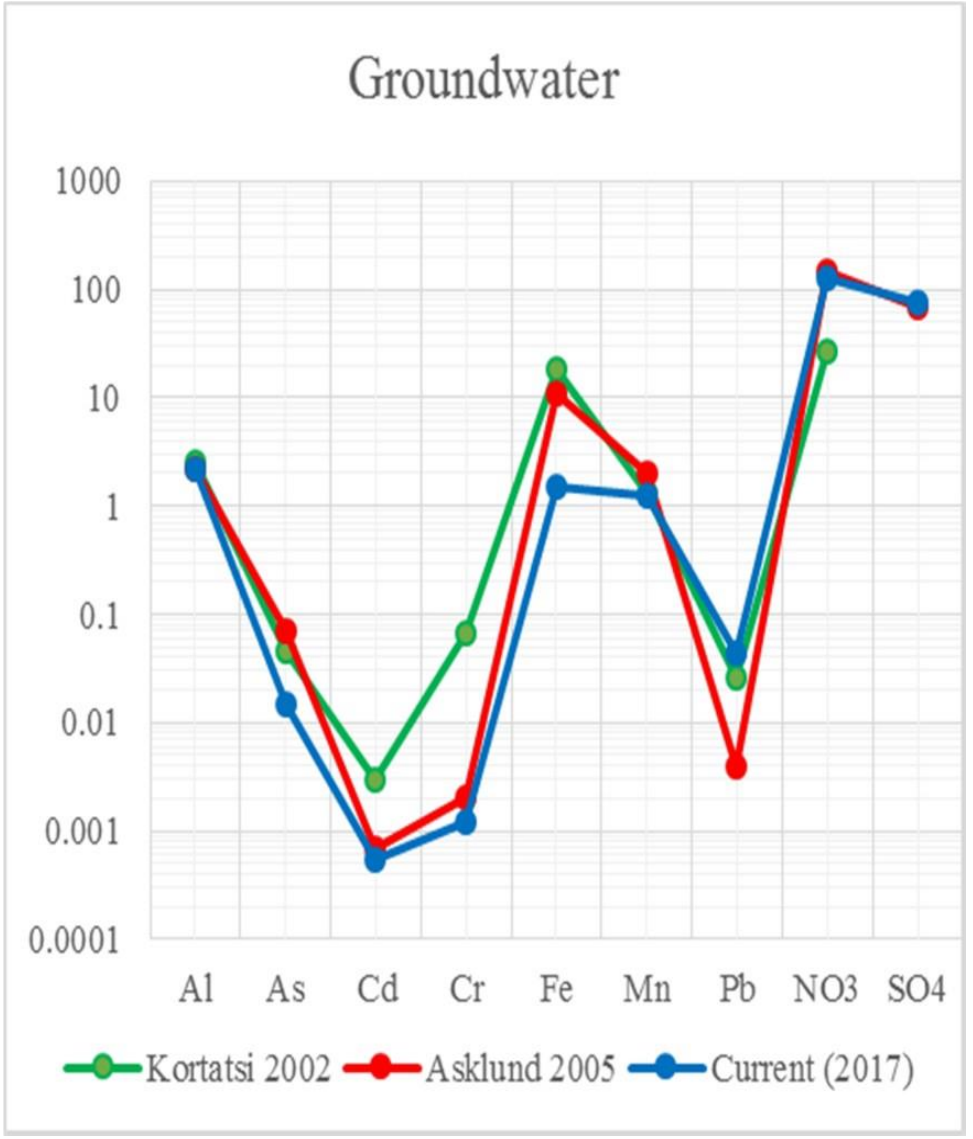


Fig. 15 Comparison of Concentration of Metals to Previous Research Works in Surface Water

Fig. 15 Comparison of Concentration of Metals to Previous Research Works in Ground Water

2b. Health Effects of Illegal Mining:

- The most toxic HM researched in the Western Region, are: Mercury, Arsenic and Lead.

- Clinical Symptoms & Investigations & lab. tests on HM toxicity, which are URGENT in the Western Region.

I. Arsenic poisoning (arsenicosis) – Health-line website (May, 2017) :

- most common cause: contaminated groundwater
- by ingestion / inhalation high levels of arsenic (a carcinogen, grey, silver or white)
- extremely poisonous to humans
- no taste, odour: makes exposure dangerous
- in nature: organic / man-made: inorganic
- often in mining-area's: high levels ground-water: USA, India, China, Mexico

Clinical Acute Symptoms (Health-line website & Mayo Clinic):

- skin: red / swollen skin; skin changes (new warts, lesions),
- digestive: abdominal pain, nausea, vomiting, diarrhoea,
- cardiac: abnormal heart rhythm, hypotension,
- headache, fever, muscle cramps, seizures, mental state changes,
- tingling of fingers and toes.

Clinical Chronic Symptoms by long-term exposure (arseniasis):

- insidious and nonspecific, mostly:
- Skin: darkening (according to WHO: within 5 years of exposure)
- Throat: constant sore
- GTI: persistent issues of nausea, epigastric pain, colic (abdominal) pains, diarrhoea
- Paresthesias of hands and feet can occur.

Physical Exam & History

Lab tests on Arsenic: of blood, urine, hair and fingernails

- urine test: for acute exposure that happened within a few days.
- blood-, hair, and fingernail tests: for chronic exposure of at least 6 months (U.S. Centres for Disease Control and Prevention) .
- All tests: - can measure high amounts of As in the body only
  - cannot determine any imminent adverse effects from exposure

Treatment: - eliminate arsenic exposure.
- full recovery after weeks / months. Dependent on
  . duration of exposure and
  . severity of the symptoms.
- Vitamin E and selenium, to limit the effects of exposure: but may cancel each other out. More research necessary.

Mayo Clinic (Mayo Foundation for Medical Education and Research, 1995-2019):

Ia. Lab. Arsenic Blood test: useful for
. detection of acute or very recent Arsenic exposure.
. monitoring effectiveness therapy

Ib. Lab. Arsenic Urine: preferred specimen for assessment of arsenic exposure

Research Info:

- As toxic forms: - inorganic As (+5) = As(V), the more toxic As(+3) = AS(III), and partially detoxified metabolites monomethyl-arsine (MMA) and dimethyl-arsine (DMA) Detoxification: in liver, as As(+3) is oxidized to AS(+5), then methylated to MMA & DMA. As(+3) & As(+5) excreted in urine shortly after ingestion, MMA & DMA predominating > 24 hrs. after ingestion.

- Blood concentrations of organic arsenic elevated short time after exposure, rapidly diminished by disappearance into tissues (because of affinity for tissue proteins). The body incorporates arsenic wherever phosphate is incorporated and excreted at the same rate as phosphate (half-life 12 dd.).

- Half-life inorganic arsenic (blood) is 4-6 hrs., Half-life of methylated metabolites: 20-30 hrs. Abnormal blood arsenic concentrations (>12 ng/ml) = significant exposure (only immediately after exposure detectable); not detectable > 2 days after exposure.

Reference Values: 0-12 ng/ml (applicable to all ages)

Interpretation:

. Abnormal blood concentrations (>12 ng/ml) indicate ‘significant exposure’
. Absorbed As is rapidly distributed into tissue sites, blood half-life < 6 hrs.
. Specimen should be drawn within 2 dd. of exposure to be detectable.

Cautions:

. Blood is NOT a good specimen to
  . screen for arsenic
  . evaluate chronic arsenic exposure
  . i.c. gadolinium-, or iodine-containing contrast media administered -→ defer sample collection 96 hrs.

Ic. Lab. Arsenic Fractionation, 24 hrs Urine:
preferred specimen for diagnosis of arsenic intoxication in 24-hrs specimens

Testing Algorithm:
1. test total arsenic. 2. if total arsenic = / > 15 mcg/l, fractionation performed, reported
3. if total arsenic < 15 mcg/l, then: reported as such, and fractionation NOT performed.

Clinical Info: s. Arsenic Blood test.
- **As-III is more toxic than As-V and both are more toxic than mono- and dimethyl-arsine.**
- **Target organs of As-III-induced effects are: heart, G.I.T., skin, epithelial tissues, kidney, and nervous system.**
- **Inorganic arsenic is carcinogenic to humans.**
- **Nontoxic, organic forms: in many foods: of which arsenobetaine and arsenocholine are the most common. Shellfish and other predators in the seafood chain have significant concentrations of organic arsenic.**
- **ingestion of arsenobetaine and arsenocholine, followed by rapid renal clearance. Organic arsenic completely excreted within 1-2 dd. after ingestion -→ no residual toxic metabolites. Biologic half-life 4-6 hrs.**
- **consistent with reporting biological exposure index (BEI), inorganic forms and methylated forms are summed and reported as 'inorganic' arsenic.**

Reference Values:

- **Total Arsenic: <18 mcg/24 hrs Inorganic Arsenic: <20 mg mcg/24 hrs. Applying to all ages.**
- **The Biological exposure indices for arsenic: 35 mcg/l, based on concentration of inorganic arsenic and methylated metabolites.**

Interpretation:

- **Quantitative reference range: only to inorganic forms applicable.**
- **Concentrations >/= 20mcg inorganic arsenic / 24 hrs, are considered toxic.**
- **No limit to normal range for organic forms, since they are not toxic and normally present after consumption of certain food types.**
- **Normal value for blood arsenic does NOT exclude a finding of elevated urine inorganic arsenic, due to the very short half-life of blood arsenic.**

Caution:

- **Evade consumption of seafood before collection of urine specimen → may result in elevated concentration of arsenic (false positive result).**

II **Mercury poisoning – Health-line website (December, 2018) :**

- most common cause: consuming too much methylmercury or organic mercury, linked to seafood.
- by ingestion / inhalation high levels of mercury (a silver coloured metal)
- most vulnerable: children and unborn babies
- in nature: organic / inorganic
- often in mining-area's: high levels ground-water: USA, India, China, Mexico

Clinical Symptoms mainly by chronic exposure (by too much Hg in the body): mainly neurological:

- anxiety, depression, irritability, memory problems, numbness, pathologic shyness, tremors
- Clinical Acute symptoms: suspect for acute poisoning

In Adults (with advanced mercury poisoning):

- hearing and speech difficulties,
- lack of coordination, muscle weakness, nerve loss in hands and face,
- trouble in walking and
- vision changes.

Children and Infants (exposed to high levels of Hg):

- disruption of foetal and early childhood development may delay:
. cognition,
. fine motor skill,
. speech and language development and
. visual-spatial awareness.

- complications: . long-term, sometimes permanent neurological changes
. especially with still developing young children
. developmental problems in the brain with
. consequent motor skill and learning disabilities

Physical Exam & History
Lab tests on Mercury: of blood, urine

Treatment: - eliminate mercury exposure. Stop eating mercury-containing seafood.
- recovery dependent on toxicity of work-place / environment.
- if mercury levels too high, chelating agents necessary: drugs removing metal from organs and disposing from the body.
- long term: treatment for neurological effects.

IIa Lab. Mercury Blood: Detecting mercury toxicity

Clinical Info:

. Mercury is essentially nontoxic in its elemental form. If Hg(0) is chemically modified to the ionized, inorganic species, Hg(+2), it becomes toxic.
. Further bioconversion to an alkyl Hg, such as methyl Hg (CH[3]Hg[+], yields a species of mercury, highly selective for lipid-rich tissues such as neurons and is very toxic.
. In industry this process is initiated by strong oxidizing agents (e.g. chorine).
. In human gut AND at bottom sediments of lakes, rives and oceans, bioconversion of Hg(0) to both Hg(+2) and alkyl Hg, CH(3)Hg(+), and (CH[3])(+2)Hg: by microorganisms
. Consequently the food chain assures consumption by larger marine animals and fish.

. Toxicity expressed in 3 ways:

- Hg(+2): readily absorbed, reacting with sulfhydryl groups of protein, causing a stereo-isomeric change in the tertiary structure of the protein.
  . Causing loss of unique activity associated with that protein.
  . Causing some proteins becoming immunogenic, eliciting Proliferation of T lympho-cytes that generate immunoglobulins to bind the new antigen.
  . Collagen tissues in particular sensitive to this.
  . Becoming concentrated in the kidney during regular clearance processes.
- Alkyl Hg species, like CH(3)Hg(+), are lipophilic and avidly bind to lipid-rich tissues, like neurons. Myelin esp. is susceptible to disruption by this mechanism.

Dental fillings:

. only 2-20 mcg/day released from dental amalgam by chewing.
. > normal, by chewing gum.
. WHO safety standard (daily exposure): 45 mcg/day.
. Therapy usually monitored by following urine output.
. Therapy terminated after urine excretion is <50 mcg/day.

Reference Values: **Normal 0-9 ng/ml. Applying to all ages.**

Interpretation:

- Quantities Hg in blood and urine correlate with degree toxicity.
- Hair analysis: to document time of peak exposure if the event was in the past.
- Normal whole blood mercury usually <10 ng/ml:
  . Individuals have mild exposure at work (dentists: up to 15 ng/ml).
  . > 50 ng/ml: indicative for significant exposure to alkyl Hg.
  . > 200 ng/ml, if exposure is due to Hg(+2)

Cautions:

- Collection procedures Trace Metals Analysis Specimen Collection & Transport.
- s. Arsenic Blood.

IIb Lab. Mercury, 24 hrs, urine:

- Useful for Detecting mercury toxicity in 24-hrs urine specimens

Clinical Info:

. Correlation levels mercury (Hg) excretion in urine and clinical symptoms: poor.
. However, urinary Hg is MOST RELIABLE way to assess exposure to inorganic Hg.

Reference Values: . 0-17 years: NOT established
. > or = 18 years: <2 mcg/24 hrs.
. toxic concentration: > 50 mcg/24 hrs.
. Concentration at which toxicity is expressed: widely variable between patients.
. 50 mcg/24 hrs. is LOWEST concentration at which toxicity is usually apparent.

Interpretation:

. > 50 mcg/day daily urine excretion: indicative significant exposure (WHO standard)

Cautions:

. to avoid contamination by dust, specimen should be collected away from site of suspected exposure

III. Lead Poisoning Drugs.com Web-site (July, 2018)

- most common cause: lead containing paint-dust, in Tarkwa: mining-waste water
- by ingestion / inhalation, gets into bloodstream, stored in organs, tissues, bones, teeth
- extremely poisonous to humans
- no taste, odour: makes exposure dangerous
- in nature: organic / man-made: inorganic
- often in mining-area's: high levels ground-water: USA, India, China, Mexico

- Increasing or prolonged exposure, lead to cause:

. permanent damage CNS, especially brain
. delayed development children
. behavioural changes in children
. decreased production of red blood cells
. hearing problems
. damage to the reproductive systems of men and women
. kidney disease
. convulsion (seizures)
. coma
. lead-poisoning of a foetus by the mother

Symptoms in Children:

- only at school-age: signs of possible
- learning disabilities, behavioural problems, mental retardation:
  with exposure of 5-25 mcg/dl blood-levels.

  with exposure of >25 mcg/dl:
- decreased production of red blood cells, tiredness and fatigue,
- headaches, severe abdominal pain and cramps, with persistent vomiting
- hearing problems, stunted growth
- convulsions
- coma

Symptoms in Adults:

with exposure of 40-50 mcg/dl: may have the same symptoms of any of:

- inability to sleep, memory and concentration problems, infertility, kidney damage, HP

Symptoms in pregnant women:

- stillbirths, miscarriages, premature births, problems in foetal neurological development

Physical Exam & History

Lab tests on Lead: of blood, eventually urine; blood test is best:

- to identify children at risk for poisoning at early age.
- for lead screening at 1 and 2 years.

Physical Exam & History

Lab tests on Lead: **of blood, eventually urine; blood test is best:**
- **to identify children at risk for poisoning at early age.**
- **for lead screening at 1 and 2 years.**

Treatment: **- several weeks, months or years for lead to leave the body (even after there is no further exposure).**
- **remove source of lead. If blood lead level is > 20 mcg/dl, chelation therapy is indicated. > 70 mcg/dl may require hospitalization.**
- **nutritious diet, iron or calcium supplements.**
- **treat the iron-deficiency anaemia in a child.**

IIIa. Lead Blood (Venous or Capillary): Detecting lead toxicity

. an HM common in man's environment that can be an acute or chronic toxin
. In USA: banned from household paints in 1978. Still in paint for nondomestic use and in artist paint pigments (e.g. in ceramic products).
. In soil near abandoned industrial sites and in weakly acidic water transported through lead or lead-soldered pipe, some foods and traditional medicine.

. Research info: Toxicity:

. its avidity **inhibits** aminolevulinic acid dehydratase and ferrochelatase, two of the enzymes catalysing synthesis of heme; leading to decreased haemoglobin synthesis resulting in **anaemia**.
. as an electrophile it avidly forms covalent bonds with the sulfhydryl group of cysteine in proteins. Thus, all tissues exposed to lead will have lead bound to them: the most common: **epithelial cells of GIT** & **proximal kidney tubules**.
. the typical diet in USA contributes 1-3 mcg/day, 1-10% absorbed.

. **Children:** absorb about 50% in dietary intake. Enhanced by nutritional deficiency.
. Majority of daily intake, excreted in stool after direct passage through GIT.
. Significant fraction absorbed, rapidly incorporated into bone and erythrocytes, lead ultimately distributes among all tissues.

. **Lipid-dense tissues (CNS esp.):** sensitive to **organic forms** of lead.
. All absorbed lead: ultimately excreted in bile or urine. Soft-tissue turnover:< 120 dd.

Treatment:

- Avoidance exposure to lead. Chelation therapy in severe cases:
  Oral dimercaprol for outpatient setting except in the most severe cases.

Reference Values: All ages: 0.0-4.0 mcg/dl
Critical Values:
. Paediatrics: (< or = 15 years: > or =20.0 mcg/dl
. Adults (> or = 16 years): > or =70.0 mcg/dl

Interpretation:

- The 95th percentile of the Gaussian distribution of whole blood lead concentration in a population of unexposed adults is below 6 mcg/dl.
- Paediatric patients, there may be an association with blood lead values of 5 to 9 mcg/dl and adverse health effects.
- Follow-up testing in 3 to 6 months may be warranted.
- Chelation therapy is indicated when whole blood lead concentration is above 25 mcg/dl in children or above 45 mcg/dl in adults.

- USA Occupational Safety and Health Administration has its own standards.
  So has Ghana (?).

Cautions: for capillary assessment: s. Arsenic Blood assessment.

IIIb. Lead, 24 hrs, urine:

Useful for Detecting clinically significant lead exposure in 24-hrs. specimens

Clinical Info:

- Increased urine lead excretion rate indicates significant lead exposure.
- Measurement of urine lead excretion rate before and after chelation therapy has been used as an indicator of lead exposure.
- An increase in lead excretion rate in the post-chelation specimen of up to 6 times the rate in the pre-chelation specimen is normal.
- Blood lead is the best clinical correlate of toxicity.

Reference Values: 0-17 years, not established. > or = 18 years: <1 mcg/24 hrs.

Reference Values:

0-17 years: not established: > or = 18 years: <1 mcg/24 hrs.

Interpretation:

. Urinary excretion <125 mcg/24 hrs: not associated with any significant lead exposure
. Urinary excretion >125 mcg/24 hrs: usually associated with pallor anaemia & other evidence of lead toxicity.

Cautions: the test is NOT a substitute for blood lead screening.

IV. Lab. Arsenic, Mercury & Lead – Hair:

- Useful for Detection Non-acute arsenic, mercury, lead exposure in hair specimen

Research Info:

- **Arsenic:**
  . Circulates in blood, will bind to protein by formation of covalent complex with sulfhydryl groups of the amino acid cysteine.
  . Keratin (major structural protein in hair/nails) contains many cysteine residues and, therefore, is one of the major sites for accumulation of arsenic.
  . Arsenic has a high affinity for keratin, the concentration of arsenic in hair is higher than in other tissues.
  . Arsenic binds to keratin at the time of exposure, trapping the Arsenic in hair. Therefore, hair analysis for arsenic is used to document exposure and when.
  . Hair collected from the nape of the neck: used to document recent exposure.
  from axillary / pubic hair: used to document long-term (6 months-1 yr.) exposure.

- **Mercury:**
  . Once absorbed, circulating, Hg becomes bound to numerous proteins, incl. keratin.
  . Mercury concentration in hair correlates with the severity of clinical symptoms.
  . If the hair can be segregated by length, such an exercise can be useful in identifying the time of exposure.

- **Lead:**
  . Hair analysis for lead can be used to corroborate blood analysis or to document past lead exposure.
  . If the hair is collected and segmented in a time sequence (based on length fro root), the approximate time of exposure can be assessed.

Reference Values:

- **Arsenic:** 0-15 years: not established. > or = 16 years: 0.0-0.9 mcg/g of hair.
- **Mercury:** 0-15 years: not established. > or = 16 years: 0.0-0.9 mcg/g of hair
- **Lead:** 0.0-3.9 mcg/g of hair. Reference values apply to all ages.

Interpretation:

. Hair grows at a rate of approx. 0.5 inch/month. Hair keratin synthesized today will protrude through the skin in approx. 1 wk.
. Thus, hair specimens collected at the skin level represents exposure of 1 wk. ago, 1 inch distally from the skin represents exposure 2 months ago, etc.

- **Arsenic:**
  . Hair arsenic levels above 1.00 mcg/g dry weight indicate excessive exposure.
  . Normally, some arsenic is present in hair from normal diet.
  . Highest hair arsenic observed in Mayo Clinic: 210 mcg/g dry weight, i.c. of chronic exposure that caused death.

- **Mercury:**
  . Hair mercury levels above 1 mcg/g indicate that exposure to more than normal amounts of mercury has occurred.
  . Normally, hair contains < 1 mcg/g of mercury.

- **Lead:**
  . Hair lead content above 10.0 mcg/g indicates significant lead exposure.
  . Normal hair lead content is < 5.0 mcg/g

4.I. Arguments for Prevention & Recommendations:

1. Galamsey practises have been continued in the Western Region, due to the corruption of the local authorities.

2. Comparing two main Statistical Studies in resp. 2010 an 2017, seems, to lead to the conclusion, (quote the Conclusion of the 2017 Study) “The general trend of water quality for the Tarkwa area is not as bad as previous studies have portrayed.“
   But: on a closer look, it turns out to lead to contrary conclusions which give reasons to criminal investigation of ‘Permit-Issuers’ and ‘Permit-Holders’, because:

   a. By deciding to use a Statistical method in 2017, different from that in 2010 it is not possible to draw conclusions about improvement of the pollution of surface and ground-waters in the Tarkwa area, since 2010.

   b. Another reason, why making statements about improvement is misleading, is, that the researchers, leave out research (and conclusions) about Mercury measurements in the 2017 study.

   c. Galamsey practice brings forth contamination of surface- and ground-waters, esp. with Hg.

d. **The local authorities in Tarkwa (AND those down-stream Bonsa-river, Ankobra-river and Pra-river systems) could know the facts (and don't care!):**
at least from 2014-November 2018, EXTENSIVE literature has been made available on the toxic effects of HM, esp. Hg, As, Pb and Cadmium on Human Health; and the W.H.O. stated in 2017, that Mercury is one of the most poisonous metals on earth.

e. **OUTSIDE the illegal Galamsey practices, Environmental practices of the Tarkwa Mine Concession holders (like Gold-field.com) or Concession extender (Tarkwa Mines) are obscured or compromised, because: no data are made available about the HM concentration in the drainage waters from/close to the certified mines.**
Those data should have been easily made available on Internet (at least)!!

- **Consequently. pollution with Heavy Metals in the Tarkwa Mine Area cannot be traced to the source of pollution (whilst in that area Galamsey is practised).**
Unless the control on filtering at source is reliable! Which requires strict assessment and application of the law, which is clearly NOT happening now!

- **Outcomes of researches on HM concentrations in surface- or groundwater AFTER 2010 are dubious or false, because:**

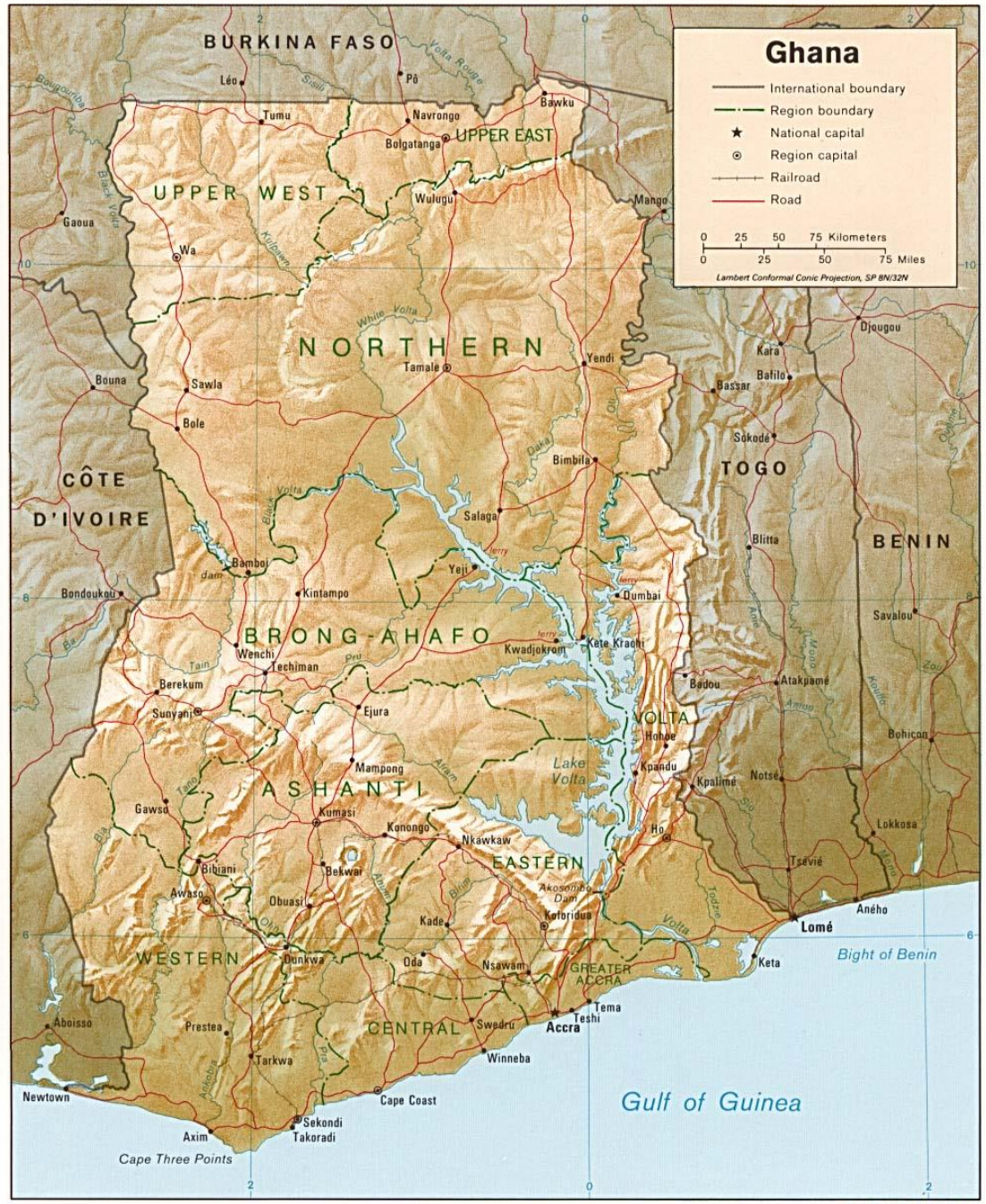
- Multi-Variate Statistical Analysis is NOT applied on the samples;
- in BOTH 2010 and 2017 studies less than 50 sampling bore-holes were allowed: for a reliable outcome you need at least 100 samples to do a Student t-test ....
- because Undue Influence of the (lower) Authorities on the Research in that area is VERY suspect (seen their interests in covering up facts):
  s. Ghana\2013- Summary-Stakeholder-Analysis- ASM and Hg Contamination

3. **Why are the surrounding areas of Tarkwa involved?** A short explanation: quote:
   "The 2015 Ghana National Drinking Water Quality Management Frame-work divides Ghana's water resources potential into surface & ground-water sources.
   Surface water resources are mainly from:

   Three river systems that drain Ghana, namely: the Volta (with White Volta basin), South Western and Coastal river systems. See: Ghana Maps:
   Ghana River Map.pdf
   Ghana_map.pdf

   s. 3.6. Ghana Maps of Main Gold-Mines:

   2019 - Spatial Distribution illegal Gold-Mining in Western Region
   2019 - Map Ghana Location Major Gold-Mines
   2019 - Map Ghana main active Gold-Mines and Drainage



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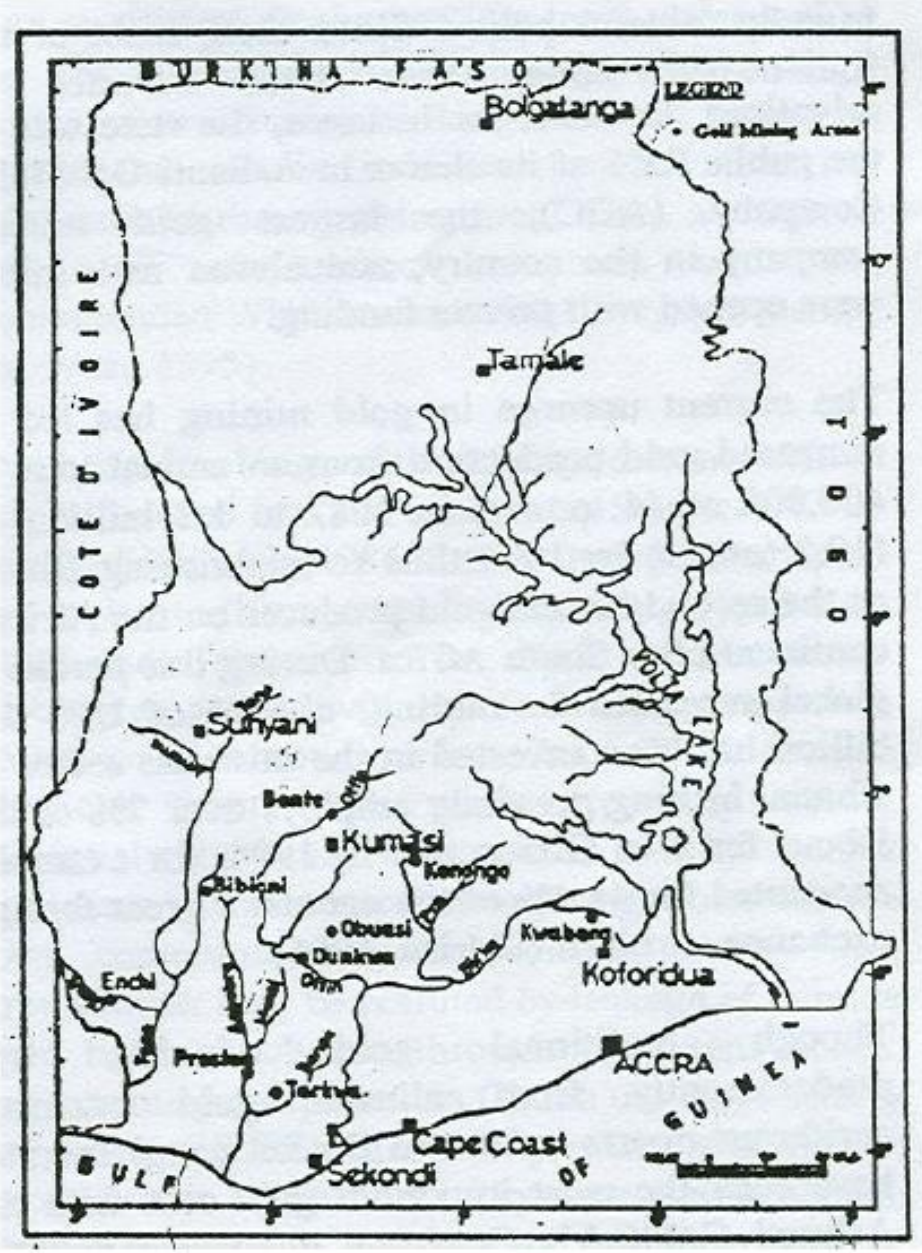
Drainage in River-systems from main Gold-Mines in Ghana:

Legends:
W.R. Western Region,
A.R. Ashanti Region,
E.R. Eastern Region

Enchi, W.R. --> Tano ---> Tano Lagoon (Cote d'Ivoire)
Bibiani, W.R. --> Ankobra
Prestea, W.R. --> Ankobra
Tarkwa, W.R. --> Ankobra
Dunkwa, A.R. --> Ofim --> Pra
Bonte, A.R. --> Ofim --> Pra
Obuasi, A.R. --> Ofim --> Pra
Konongo, A.R. --> Pra
Kwabeng, E.R. --> Birim --> Pra

Map of Main active Gold-mines in Ghana, today



The South-Western river system is made up of the Bia Tano, Ankobra and Pra rivers. Making up a total of 22% of Ghana's land area. Five basins namely: Densu River, Ankobra, Pra, Tano and White Volta basin.

The bare eye perceives there is something wrong with the water-quality of a dirty-brown-coloured water of the river Pra.

4. ALL drainage from the Tarkwa area (Ankobra-river-system) and Pra-river-system in the Gulf will contaminate the fish in the Guinea Gulf (including Takoradi-Sekondi coast). So duping the whole coastal population!
   In summer-time that drainage RETURNS land-inward by the South-North wind, so increasing the pollution-level of the sewage-system at the South-coast of Ghana.

   a. Research in HM contamination of fish in the Gulf has confirmed esp. Hg concentrations to be above the WHO standards (s. lit., Health Effects of Heavy Metals, G. 2018-11 Summary – Mercury and Arsenic (in sea-food) –AACC.org).

   b. Water which is polluted with HM, is neither suitable for irrigation, because it serves to produce food. S. research HM Food Pollution in / down-stream the Tarkwa-area.

5. Is the GWCL pipe-water free from HM?? To answer that question, discussion follows:

a. The Pipe-water is delivered by the GWCL, ONE of the Service Providers in the sense of the National Drinking Water Quality Management Framework for Ghana (June 2015).
The other providers being the Private Sector Operators: Tankers, Self-suppliers and National Disaster Management Organization. The GWCL water source is the Pra, filtering it to potable(?) water. Such as known the river Pra is harassed by Galamsey.

b. Even the National Drinking Water Quality Management Framework for Ghana of June 2015 does NOT subsume Arsenic under 'Constituents of Health Significance'!! (s. Table 19, slide 74);

c. Those Standards have been adopted from those of the W.H.O. Now, as to especially Hg and As, the ASSESSMENT-DATES ARE OUT-DATED: resp. 2011 and 2004 (!!);

d. One may argue: 'I only drink water from sachets, so, not from the pipes of our GWCL (THE ONLY supplier of water through Government pipes): A WRONG PREMISE IN THE ARGUMENT. Now, here is the catch or thorn in the flesh of the stake-holder (which is you, me and he, she, living in the Western Region): you are hooked, if you belief the sachet story:

BECAUSE the quality of water from Tarkwa and river Pra is impaired AT LEAST from Galamsey practices, the Ghana Water Company had to RESTRICT its capacity (see recent Press-state-ments in 2017, s. (2017-3) Ghana W. R. loses 5.3m gallons of water daily to Galamsey):

- Price of water-units increased.
- Uncertain quality of the water.
- Costs of water-filtering should be born by the polluter, cq the mining industries and individuals: NOT BY GHANA'S GOVERNMENT! because:
  - quality-standard of that water is required by law, and
  - water is a primary commodity: the price-increase will react sharply to restriction of supply (an economic law)

6. The FACTS:
- close to six million people (nearly 22 %) rely on surface water to meet daily needs.
- 67 % of Ghanaians lack access to improved sanitation / entirely without toilets.
- 70 % of all diseases in Ghana are caused by unsafe water and poor sanitation!!
- those living in poverty often pay up to 10 x more per litre water service = costs of filtering saved by the illegal practices of illegal miners!!
- an estimated 58.4 % of Ghanaians and 81% of the Rural population in Ghana: NO access to potable water s. (2018-11) Review of Customary Water Laws and Practices in Ghana A. Sarpong
- Clean, streaming water reduces drastically water-born diseases!
- The unrestricted mining activities in the Ankobra and Pra River Systems have caused increasingly more difficult to control: erosion and deforestation, corruption in mining activities, deterioration of the health-state of the population, with shortages of potable water, in those River Systems.

And so cause in the end: a Water War ...

4.II. Conclusion of Arguments for Prevention & Recommendations:

1. **Generally, all uncontrolled Mining activities pose a hazard-risk for down-stream areas, populated or not. Consequently:**

2. **Authorities and Chiefs responsible for uncontrolled Mining activities, in the Tarkwa area, down-stream Bonsa river AND down-stream Pra River System, seem to collude.**
   A kind of Western Region Mafiosi terrorizes the people of Ghana in the Western Region. Since China is the biggest gold-producer, Chinese sellers are the greatest suspects for pushing the Mercury in the supply-chain.
   They break the Fundamental Laws of Human Rights, because:
   a. **Water is the FIRST elementary substance and requirement of the human body: eight glasses of (fresh) water required, in Africa, for normal body function of a grown-up;**
   b. **the allowed Galamsey practice WITH obscured environmental practices of the Tarkwa Mines cause**
      . **rationing of pipe-water (by G.W.C.L.) and**
      . **leave the people of the Western Region in uncertainty about the quality of the pipe-water delivered by G.W.C.L. and put surface-water users at a LIFE-THREATENING hazard (up to 81% of the Rural Population!!);**

3. **The lesson the miners have to take to heart: you CANNOT evade drinking-water (esp. HM caused) filtering costs;**

5a. What is imperative to clean the mess (lit. & fig.)?

I. Transparency in mining practices and Ghana's health-protective measures

II. a. Institution of Water-Watch-Groups as representatives of all stake-holders: a broader representation of society than the construction mentioned in the Constitution of the Ghana Water Cie.

b. Replacement of the complete Club of assigned Inspectors.

III.1. Elimination of Arsenic in waste-water at source,

2. Reduction of all other toxic Heavy Metals in mining-waste-waters,

3. URGENT UPDATE to RECENT Scientific standards.

s. the case-study Asante Mining Area.

s. W.H.O. Fact sheets Arsenic and Mercury, with Assessment dates

ASSESSMENT DATES are out-dated: resp. 2011 (As) and 2004 (Hg) !!

IV. a. Bring Polluters & Perpetrators to justice:

Any cover-up in this respect (s. the 2017 Research) constitutes a breach of

. Ghana's Constitution (Constitution of 1992 – 1996),
. Preamble (the protection and preservation of Fundamental Human Chapter 5 (Fundamental Human Rights & Freedoms) esp. Article 15, 17, 28 and 31 should be called in and
. U.N. Universal Declaration of Human Rights especially art. 25 (1), (2), so leading to

i. persecution of the Perpetrators due to criminality.
ii. law-suites against the Polluters due to liability as well.

b. the President may take the initiatives mentioned in Ghana's Constitution. Part II Emergency Powers Art. *31 EMERGENCY POWERS (1) – (10)*

Bring Polluters & Perpetrators to justice through FAST-TRACK COURT-PROCEDURES: NOT by years-wasting court-procedures.
To that end, the advice from Chief-Justice Mrs. Georgina Theodora Wood should be sought, to accelerate the procedures.

The providers of toxic HM to illegal miners should be prosecuted as well: they are the primary, secondary, active and key-stakeholders in ASM!!

How?

BY CO-ORDINATION between the POLICE SERVICE, ARMED FORCES, BNI (Ghana Secret Service) and INTERPOL is imperative (considered the intervention by China in the African Union since 2000 (espionage), since the establishment of the CHINA-A.U.-COOPERATION PLATFORM in 2000).

V a. - To reveal the real state of pollution, I advise to assign research (in pollution by H.M. of ground-water, surface-water and pipe water of G.W.C. in the Western Region) to an independent Research-institute.
- The choice should fall especially and preferably on an Institute from a non-ex-colonial country. Why?

- to forestall prejudice by 'incompatibilité des fonctions et des interests',
- to save Ghana from disasters due to an unbridled mining-industry polluting 'my people'.
- to honour the efforts and wishes of Ghana-founding President Nkruma to promote irrigation for the whole of West Africa.
- the results of that research becoming a base for management of the G.W.C.L. cq. WRC.

V b. For Management in cleaning up the surface-water resources for GWC-L, the identification of the gold-mines draining rivers Tano, Ankobra and Pra is significant. Because it will be of great help to introduce Progress-Report systems: an instrument to monitor the clean-up AND identify sources of pollution!

VI Introduce, as soon as possible, law-enforced non-toxic gold-extraction methods!!

5b. And the Way Forward:

Are there Alternative Methods of Winning Gold, other than those using the toxic Mercury or Cyanide? The answer is: YES!!

IA. Mercury suppliers in Ghana (NOT an exhaustive list) (Google):

- Global Gold Mercury *Suppliers* and Gold Mercury

IB. Example of Mining-Industry with a DUBIOUS MISSION:

- the Chinese Company Xinhai, Mineral Processing EPC

propagates (quote) "Artisanal and Small Scale Gold Mining Without Mercury (with the argument): The Mina Mata Convention on Mercury, a global agreement for reducing mercury pollution." At the same time propagating a TOXIC method with Tanzania as a success-story.

II. Examples of Toxic-free chemical Gold-Extraction Methods in use:

A. (Mother Nature Net, May 15, 2013) replace toxic cyanide with plain old corn-starch:

Researchers stumbled upon a method of a corn-starch chemical process:

- a clean, cheap method, discovered by accident.

B. (4 Jan. 2019) https://www.911metallurgist.com/blog/mercury-free-gravity-borax-method:

(GBM) mentions to Leach Gold Without Cyanide: to quote

- ".. requires the same equipment as the amalgamation methods: the heavy mineral concentrate is mixed with borax powder; by blowtorching the mix, the borax melts and the gold sinks to the bottom."

- yields more gold, under identical conditions, than the traditional amalgamation method.

- Draw-back: ineffective in areas using whole-ore amalgamation, since up to 90% of the mercury is lost to the tailings (the waste product consisting of fine sand) and only 10% is lost by blowtorching of amalgam. Thus GBM is not widely used outside Benguet (Philippines)"

C. https://patents.google.com/patent/CN101157986A/en:

- relates to a wet gold extraction method, and
- is quick
- uses the solution of sodium bromate; chloride; vitriol; polyurethane foam; sodium sulphite; oxalic acid; hydrochloride; only 2% sulphur.
- the gold leaching speed is a few to a dozen times as fast as that in cyanidation."

III. Examples of Chemical-free Gold-Extraction Methods in use:

D. http://www.extrac-tec.com: " EXTRAC-TEC claims, quote,

- that Heavy Particle Concentration (HPC) technology enables
- cost-effective gravity separation of minerals (differing densities) without use of chemicals.
- recovery rates: superior to any other equipment, minimizing losses and maximizing financial performance.

E. https://www.lunastrumsv.nl/project/ or Crusher.online propagates

- non-chemical gold-extraction methods, with many Projects in several nations.

So, what seems to be the way forward? Such as suggested, the methods:

- A or B, perhaps C, are suitable for Small-gold-mining and
- C, D or E may serve Intermediate and Large-gold-mining Industries, in Ghana.

To Exit →>